CLAIMS

What is claimed is:

1. A microfluidic device comprising:

a body having at least one microscopic fluid flow channel therein, the microscopic fluid flow channel being defined by a channel wall having a fluid contact surface portion, said fluid contact surface portion comprising a substrate with a multiplicity of substantially uniformly shaped and dimensioned asperities thereon, said asperities arranged in a substantially uniform pattern, each asperity having a cross-sectional dimension and an asperity rise angle relative to the substrate, the asperities spaced apart by a substantially uniform spacing dimension and positioned so that the surface has a contact line density measured in meters of contact line per square meter of surface area equal to or greater than a critical contact line density value "Λ_L" determined according to the formula:

$$\Lambda_L = \frac{-P}{\gamma \cos\left(\theta_{a,0} + \omega - 90^\circ\right)}$$

where P is a predetermined maximum expected fluid pressure value within the fluid flow channel, γ is the surface tension of the liquid, $\theta_{a,0}$ is the experimentally measured true advancing contact angle of the liquid on the asperity material in degrees, and ω is the asperity rise angle; and wherein the ratio of the cross-sectional dimension of the asperities to the spacing dimension of the asperities is less than or equal to 0.1.

2. The device of claim 1, wherein the asperities are projections.

3. The device of claim 2, wherein the asperities are polyhedrally shaped.

4. The device of claim 2, wherein each asperity has a generally square cross-section.

5. The device of claim 2, wherein the asperities are cylindrical or cylindroidally shaped.

6. The device of claim 1, wherein the asperities are cavities formed in the substrate.

7. The device of claim 1, wherein the asperities are parallel ridges.

8. The device of claim 7, wherein the parallel ridges are disposed transverse to the direction of fluid flow.

9. The device of claim 1, wherein the asperities have a substantially uniform asperity height relative to the substrate portion, and wherein the asperity height is greater than a critical asperity height value "Z_c" in meters determined according to the formula:

$$Z_c = \frac{d\left(1 - \cos\left(\theta_{a,0} + \omega - 180^\circ\right)\right)}{2\sin\left(\theta_{a,0} + \omega - 180^\circ\right)}$$

where d is the least distance in meters between adjacent asperities, $\theta_{a,0}$ is the experimentally measured true advancing contact angle of the liquid on the asperity material in degrees, and ω is the asperity rise angle in degrees.

10. A process of making a microfluidic device comprising steps of:

forming at least one microscopic fluid flow channel in a body, the fluid flow channel being defined by a channel wall having a fluid contact surface portion; and

disposing a multiplicity of substantially uniformly shaped asperities in a substantially uniform pattern on the fluid contact surface portion, each asperity having a cross-sectional dimension and an asperity rise angle relative to the fluid contact surface, the asperities spaced apart by a substantially uniform spacing dimension and positioned so that the surface has a contact line density measured in meters of contact line per square meter of surface area equal to or greater than a critical contact line density value "Λ_L" determined according to the formula:

$$\Lambda_L = \frac{-P}{\gamma \cos\left(\theta_{a,0} + \omega - 90^\circ\right)}$$

where P is a predetermined maximum expected fluid pressure value within the fluid flow channel, γ is the surface tension of the liquid, $\theta_{a,0}$ is the experimentally measured true advancing

contact angle of the liquid on the asperity material in degrees, and ω is the asperity rise angle; and wherein the ratio of the cross-sectional dimension of the asperities to the spacing dimension of the asperities is less than or equal to 0.1.

11. The process of claim 10, wherein the ratio of the cross-sectional dimension of the asperities to the spacing dimension of the asperities is less than or equal to 0.01.

12. The process of claim 10, wherein the asperities are formed by a process selected from the group consisting of nanomachining, microstamping, microcontact printing, self-assembling metal colloid monolayers, atomic force microscopy nanomachining, sol-gel molding, self-assembled monolayer directed patterning, chemical etching, sol-gel stamping, printing with colloidal inks, and disposing a layer of carbon nanotubes on the surface.

13. The process of claim 10, wherein the asperities are formed by extrusion.

14. The process of claim 10, further comprising the step of selecting a geometrical shape for the asperities.

15. The process of claim 10, further comprising the step of selecting an array pattern for the asperities.

16. The process of claim 10, further comprising the steps of selecting at least one dimension for the asperities and determining at least one other dimension for the asperities using an equation for contact line density.

17. The process of claim 10, further comprising the step of determining a critical asperity height value "Z_c" in meters according to the formula:

$$Z_c = \frac{d\left(1 - \cos\left(\theta_{a,0} + \omega - 180^\circ\right)\right)}{2 \sin\left(\theta_{a,0} + \omega - 180^\circ\right)}$$

where d is the least distance in meters between adjacent asperities, $\theta_{a,0}$ is the true advancing contact angle of the liquid on the surface in degrees, and ω is the asperity rise angle in degrees.

18. A microfludic fluid flow system including at least one microfluidic device, the device comprising:

a body having at least one microscopic fluid flow channel therein, the microscopic fluid flow channel being defined by a channel wall having a fluid contact surface portion, said fluid contact surface portion comprising a substrate with a multiplicity of substantially uniformly shaped and dimensioned asperities thereon, said asperities arranged in a substantially uniform pattern, each asperity having a cross-sectional dimension and an asperity rise angle relative to the substrate, the asperities

spaced apart by a substantially uniform spacing dimension and positioned so that the fluid contact surface portion has a contact line density measured in meters of contact line per square meter of surface area equal to or greater than a critical contact line density value "Λ_L" determined according to the formula:

$$\Lambda_L = \frac{-P}{\gamma \cos\left(\theta_{a,0} + \omega - 90^\circ\right)}$$

where P is a predetermined maximum expected fluid pressure value within the fluid flow channel, γ is the surface tension of the liquid, $\theta_{a,0}$ is the experimentally measured true advancing contact angle of the liquid on the asperity material in degrees, and ω is the asperity rise angle; and wherein the ratio of the cross-sectional dimension of the asperities to the spacing dimension of the asperities is less than or equal to 0.1.

19. The system of claim 18, wherein the asperities are projections.

20. The system of claim 19, wherein the asperities are polyhedrally shaped.

21. The system of claim 19, wherein each asperity has a generally square cross-section.

22. The system of claim 19, wherein the asperities are cylindrical or cylindroidally shaped.

23. The device of claim 18, wherein the asperities are cavities formed in the substrate.

24. The device of claim 18, wherein the asperities are parallel ridges.

25. The device of claim 24, wherein the parallel ridges are disposed transverse to the direction of fluid flow.

26. The device of claim 18, wherein the asperities have a substantially uniform asperity height relative to the substrate portion, and wherein the asperity height is greater than a critical asperity height value "Z_c" in meters determined according to the formula:

$$Z_c = \frac{d\left(1 - \cos\left(\theta_{a,0} + \omega - 180^\circ\right)\right)}{2\sin\left(\theta_{a,0} + \omega - 180^\circ\right)}$$

where d is the least distance in meters between adjacent asperities, $\theta_{a,0}$ is the experimentally measured true advancing contact angle of the liquid on the asperity material in degrees, and ω is the asperity rise angle in degrees.